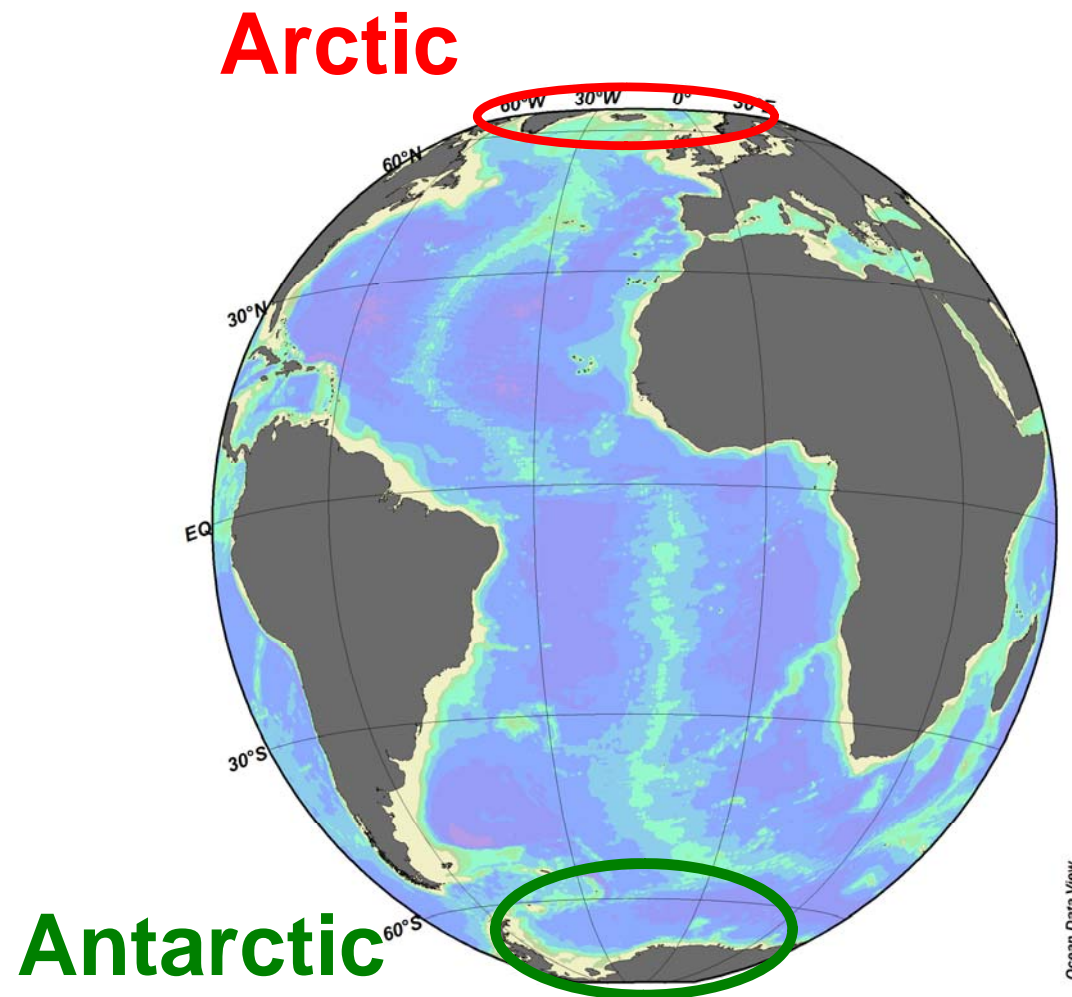


# Using Argo under sea ice

Olaf Klatt  
Olaf Boebel  
Eberhard Fahrbach

Alfred-Wegener-Institut, Bremerhaven

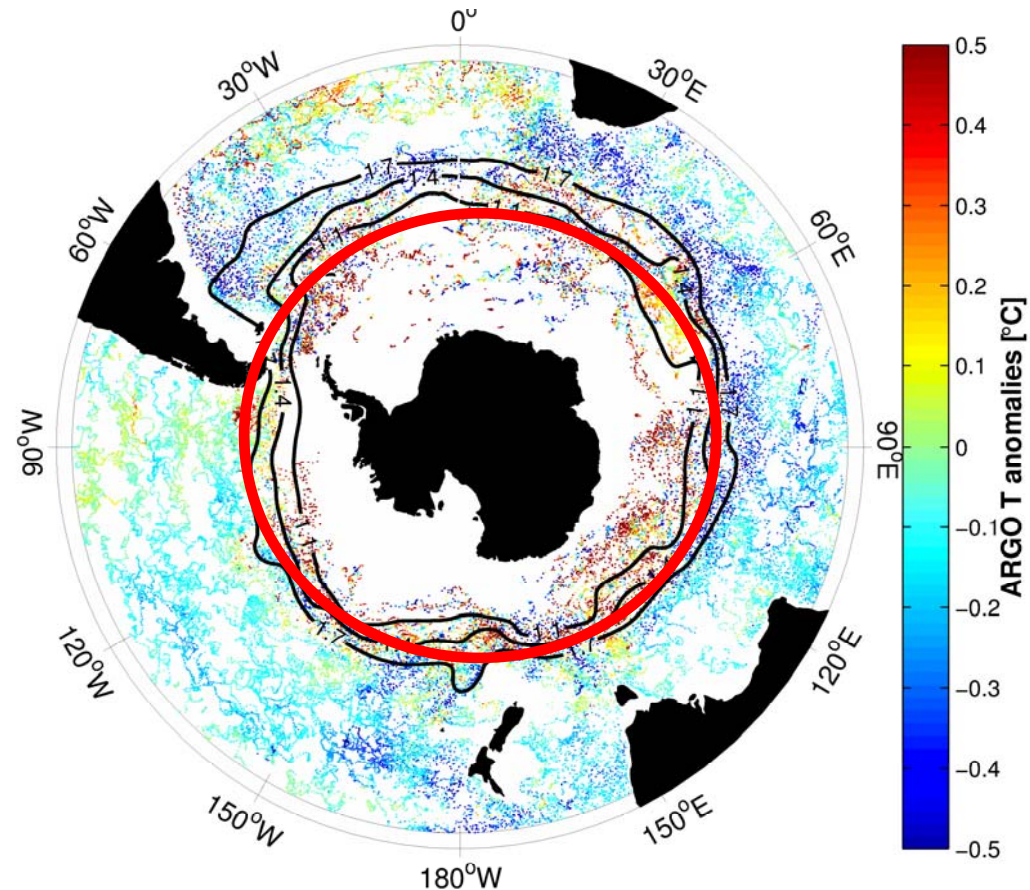


# Climate variability

Polar regions play a critical role in setting the rate and nature of global climate variability, e.g.

- heat budget
- freshwater budget
- carbon budget

**In the past the high latitude oceans have been drastically under-sampled, particularly in winter**



Temperature anomalies from the climatological mean  
(Böning et al..2008)

# Outline

- Introduction
- Towards ice compatible floats
  - Antarctic (Weddell Sea) realisation
    - Ice Sensing Algorithm
    - Interim Store
    - RAFOS-Receivers
    - Array of Sound sources
  - Arctic planning
    - Arctic ISA
    - Physical Ice Protection

# Ice compatibility of Argo floats: a 3 step process

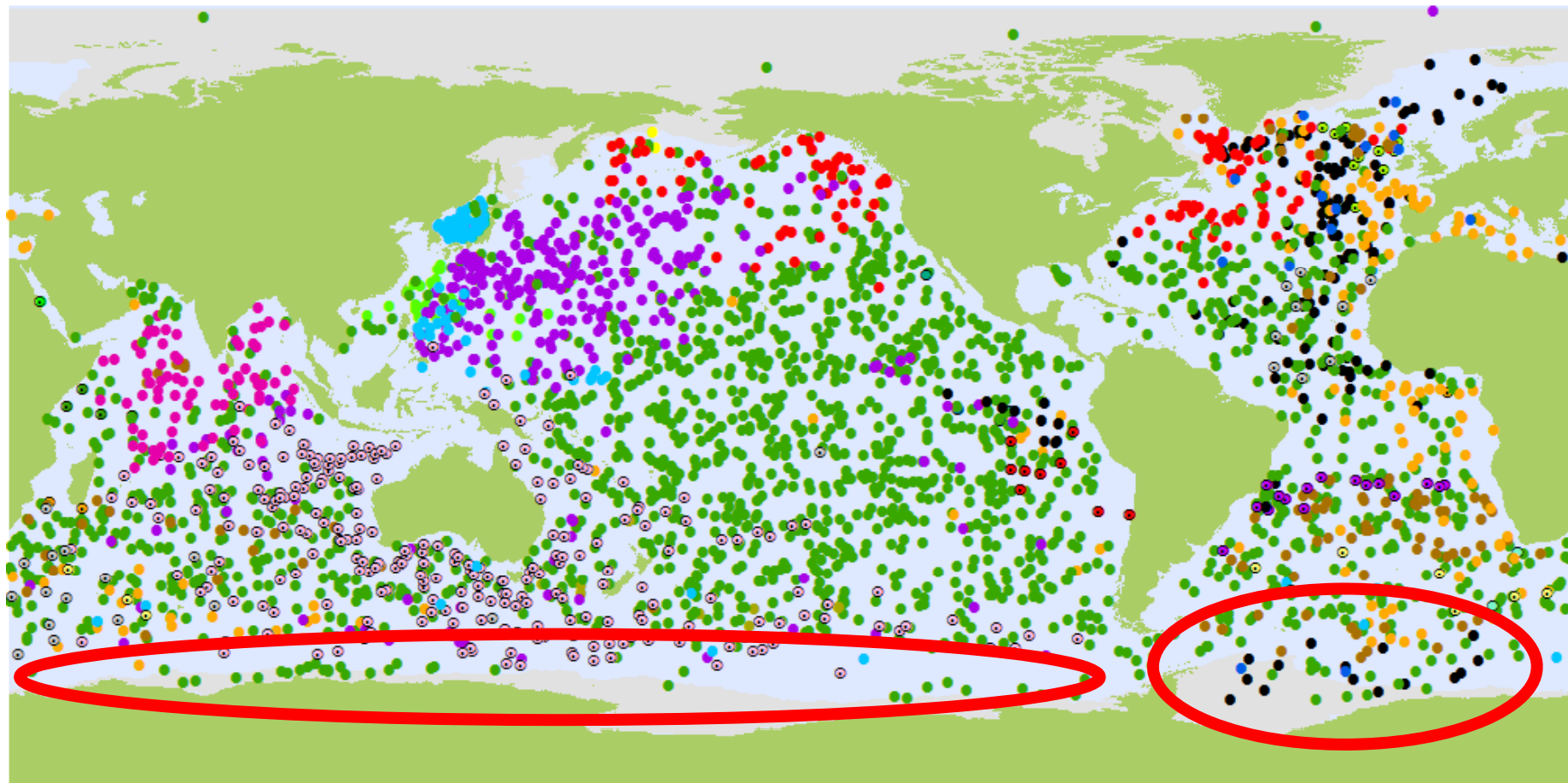
Ice protection (ISA, aISA)	Interim storage (iStore)	Under Ice location (RAFOS)
<p>Aborts ascent when sea – ice is expected at the surface protects the fragile parts against the ice pressure</p>	<p>Provides delayed mode profile when surfacing impossible</p>	<p>Provides subsurface profile position when surfacing impossible</p>
<p>Successful (Weddell Sea) Arctic update under test</p>	<p>Successful (Weddell Sea) No update is needed</p>	<p>Successful (Weddell Sea) Installation of a small array is planed</p>

# Weddell Sea solutions

- **Ice protection: Antarctic ice sensing was defined**  
If the median of the temperature between 50db and 20db ( $T_{|p=(50,45,40,35,30,25,20 \text{ dbar})}$ ) is less  $-1.79 \text{ }^\circ\text{C}$  abort surface attempt

→ Increased the “survival probability” and doubled the life time of floats in ice invested areas.

# Recent Argo float distribution



3149 Argo Floats

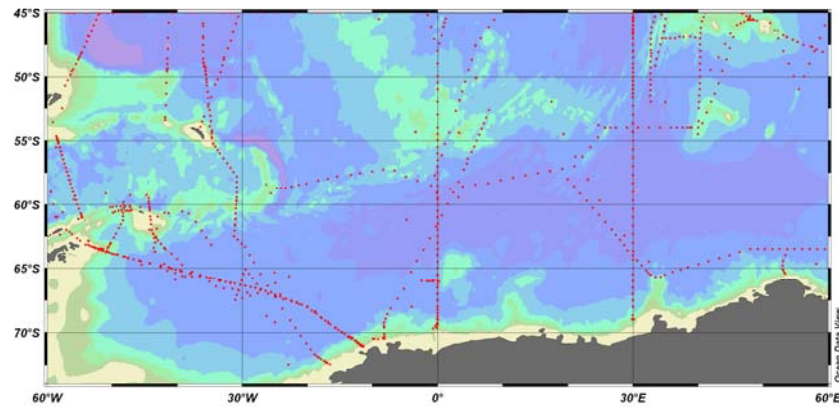
May 2010

○ ARGENTINA (10)	● CHINA (29)	● GERMANY (142)	● SOUTH KOREA (92)	● NORWAY (0)	● SPAIN (1)
○ AUSTRALIA (253)	● ECUADOR (3)	● INDIA (73)	● MAURITIUS (2)	● POLAND (0)	● UNITED KINGDOM (107)
● BRAZIL (16)	● EUROPEAN UNION (14)	● IRELAND (10)	● MEXICO (1)	● RUSSIAN FEDERATION (2)	● UNITED STATES (1781)
● CANADA (130)	● FRANCE (145)	● JAPAN (287)	● NETHERLANDS (25)	● SAUDI ARABIA (1)	
● CHILE (9)	● GABON (1)	● KENYA (4)	● NEW ZEALAND (9)	● SOUTH AFRICA (2)	

jcommops  
JOINT OCEANOGRAPHIC COMMISSION

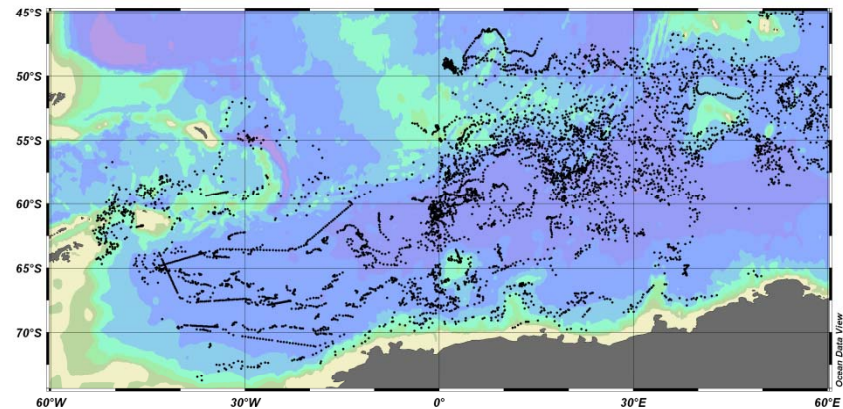
# Weddell Sea data

**WOCE: CTD-stations**



1100 CTD casts

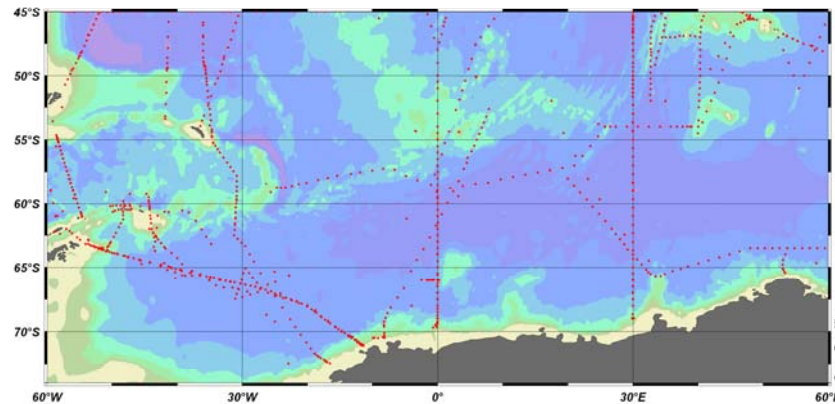
**AWI floats**



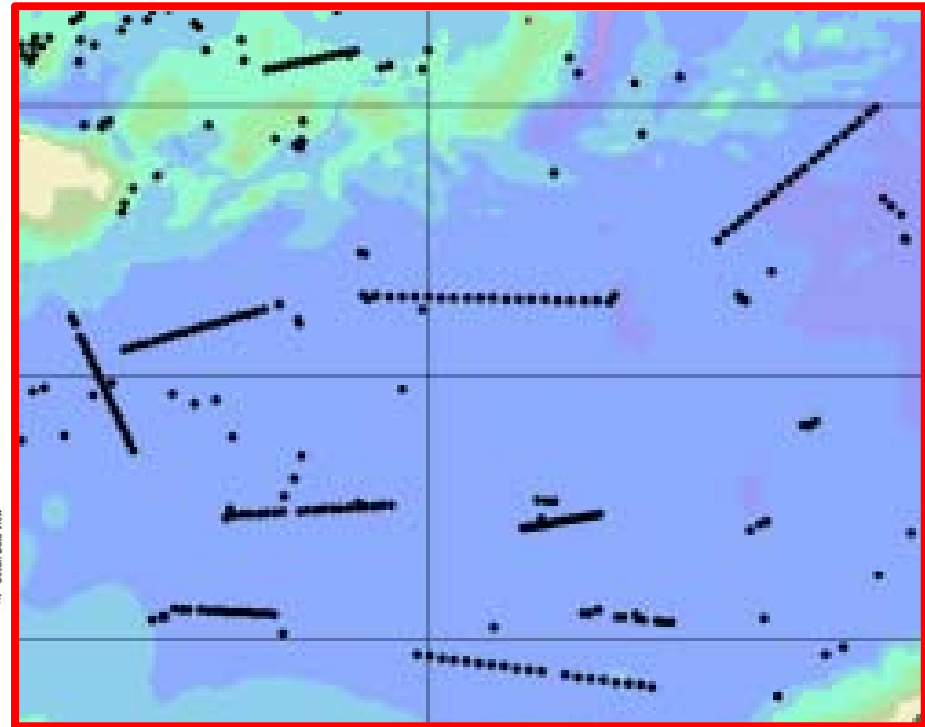
7000 float profiles

# Weddell Sea data

**WOCE: CTD-stations  
winter**



**< 300 CTD casts**





# Weddell Sea solutions

- Ice protection: Antarctic ice sensing was defined

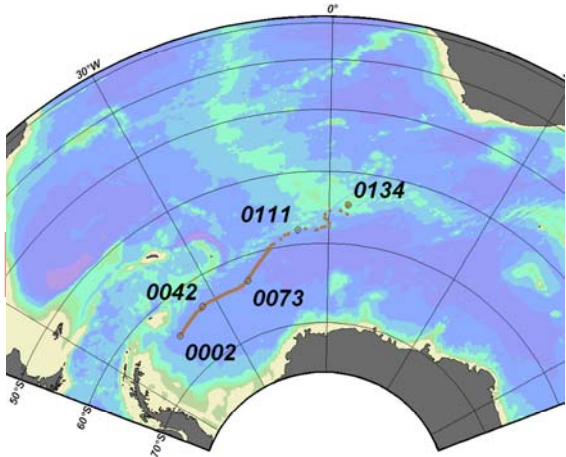
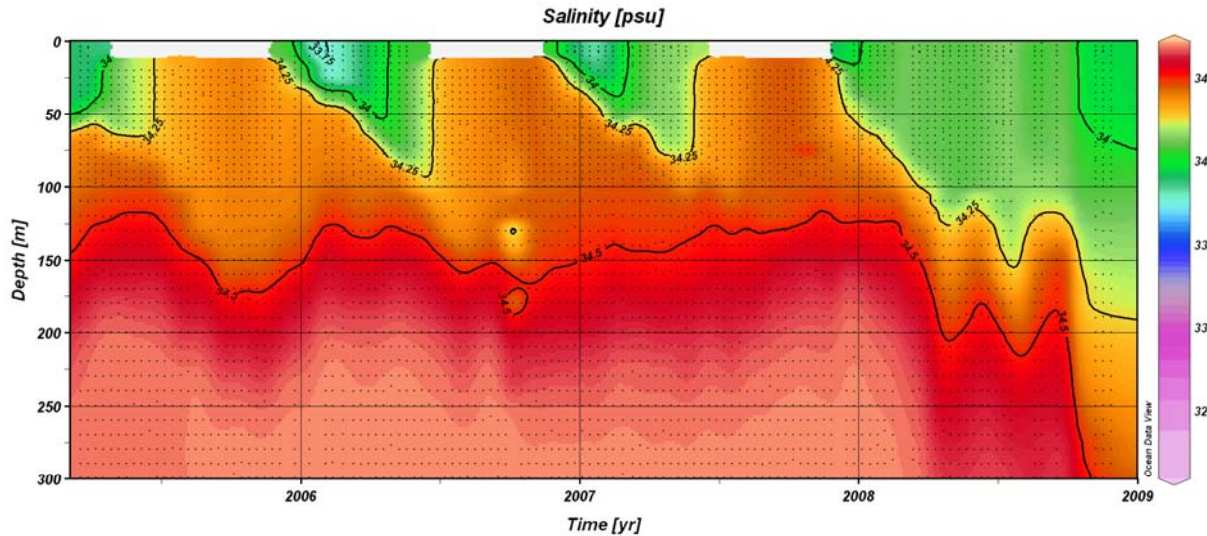
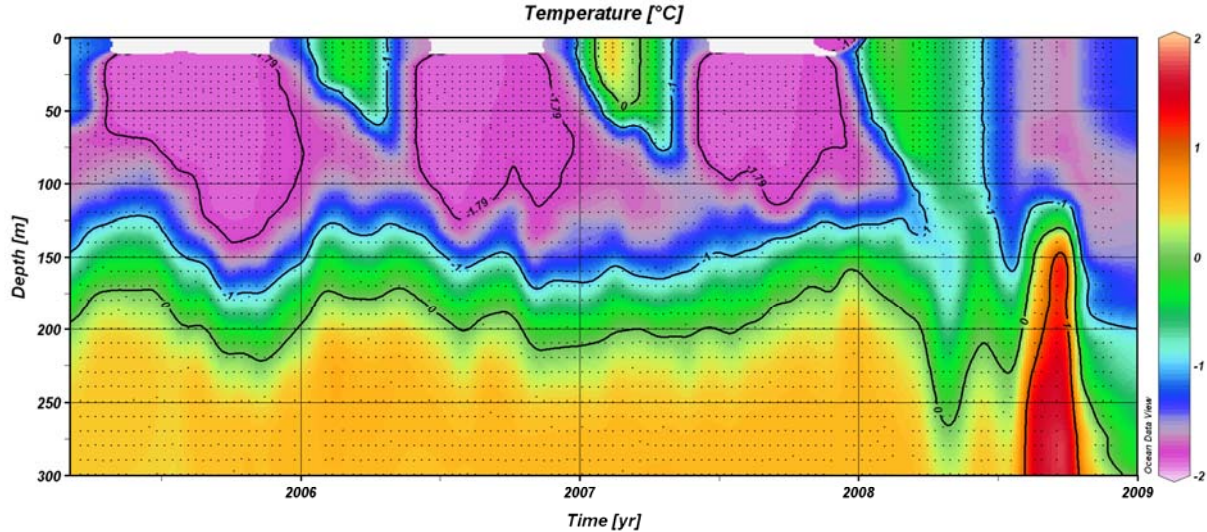
If the median of the temperature between 50db and 20db ( $T_{|p=(50,45,40,35,30,25,20 \text{ dbar})}$ ) is less 1.79 °C abort surface attempt

→ Increased the “survival probability” and doubled the life time of floats in ice invested areas.

- **Interim storage (iStore) was established**

→ For the first time a noteworthy amount of data obtained in ice covered areas.

# Temperature and Salinity Cycle



AWI\_088

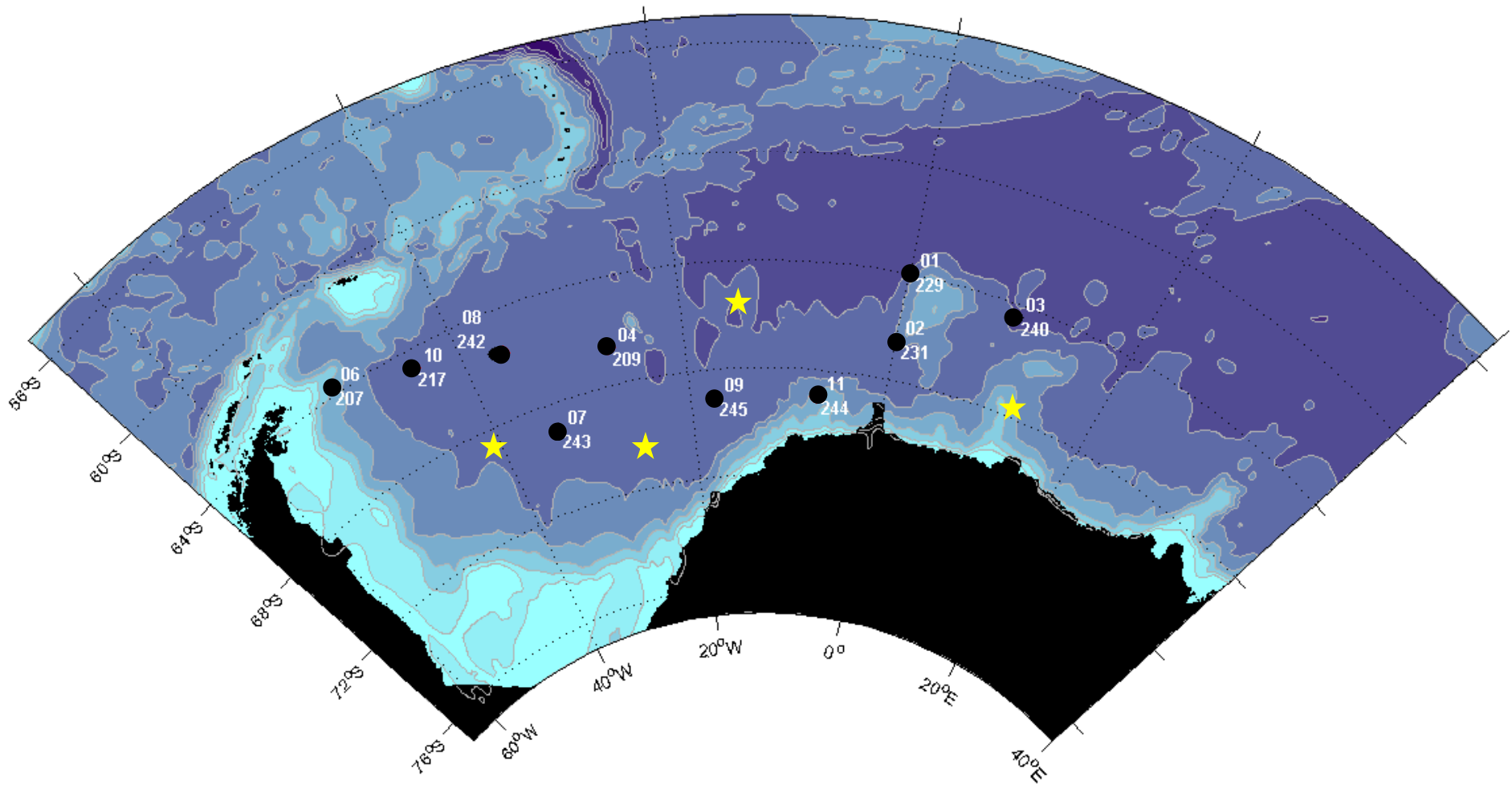
wmo number: 7900086



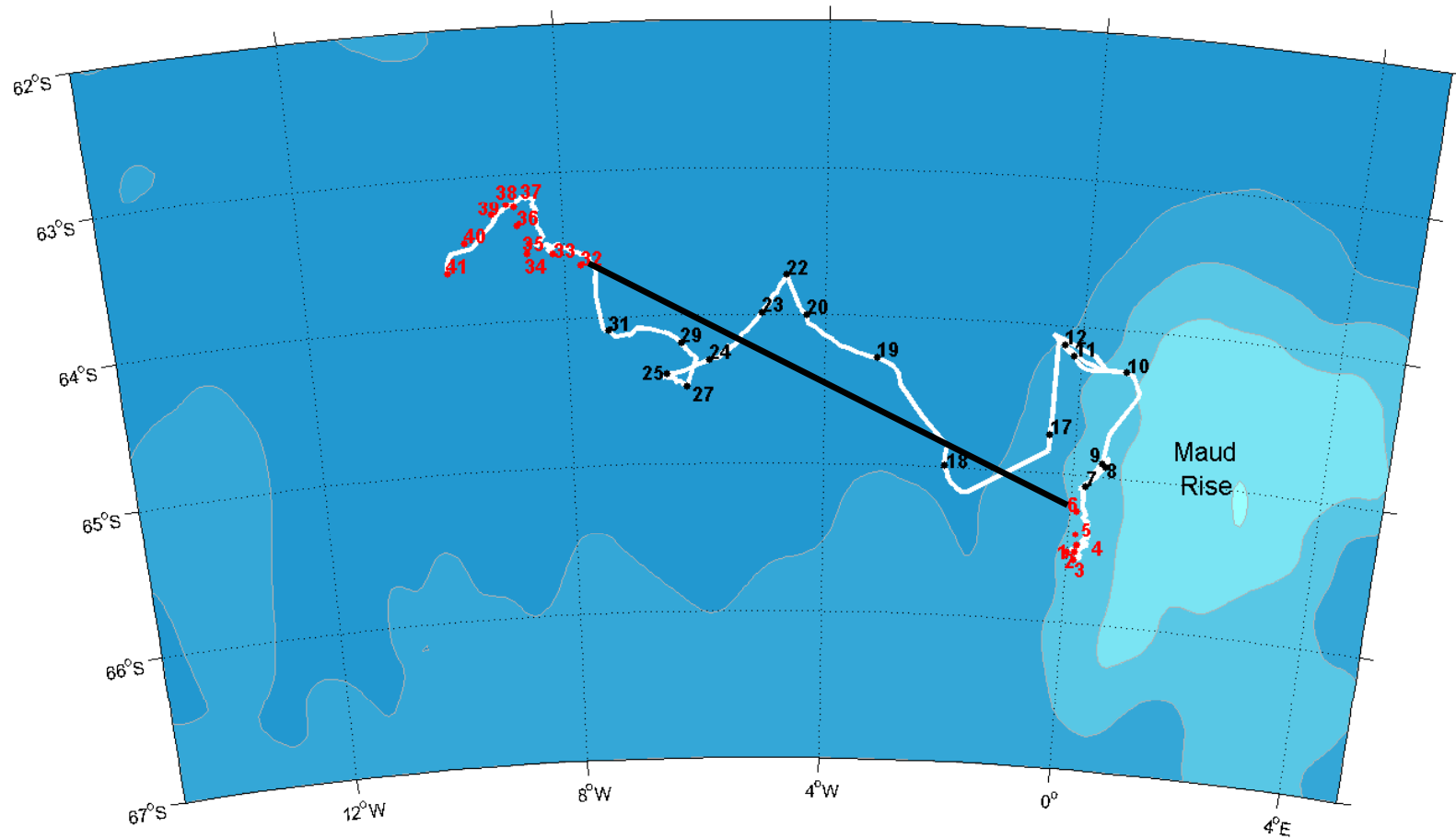
# Weddell Sea solutions

- Ice protection: Antarctic ice sensing was defined
  - If the median of the temperature between 50db and 20db ( $T_{|p=(50,45,40,35,30,25,20 \text{ dbar})}$ ) is less 1.79 °C abort surface attempt
  - Increased the “survival probability” and doubled the life time of floats in ice invested areas.
- Interim storage (iStore) was established
  - For the first time a noteworthy amount of data obtained in ice covered areas.
- **Under ice location: RAFOS technique**
  - geo-referenced under ice profiles

# Under ice location: 2009: array of 10 Sound Sources installed



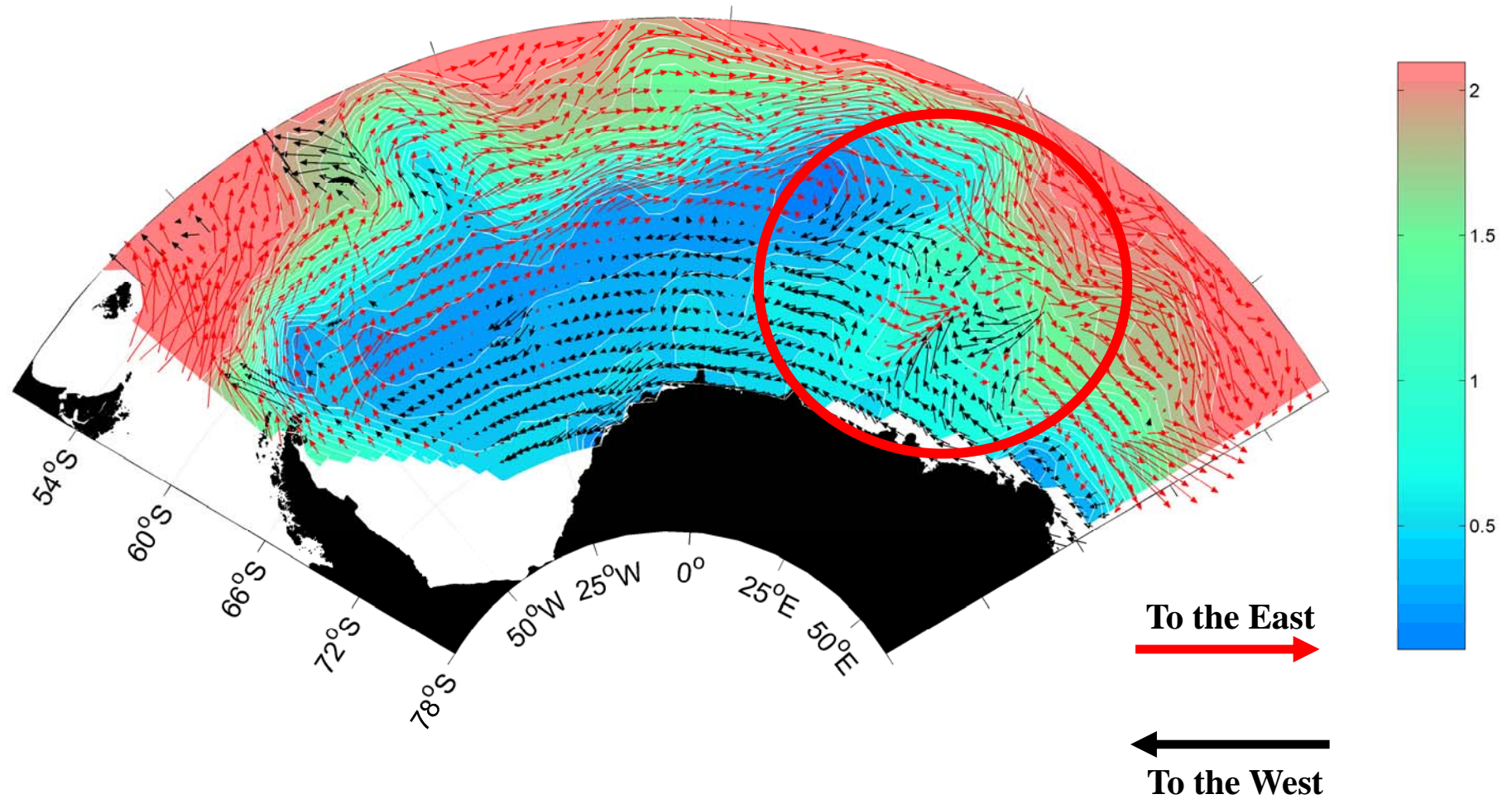
# Subsurface trajectory



# Weddell Sea solutions

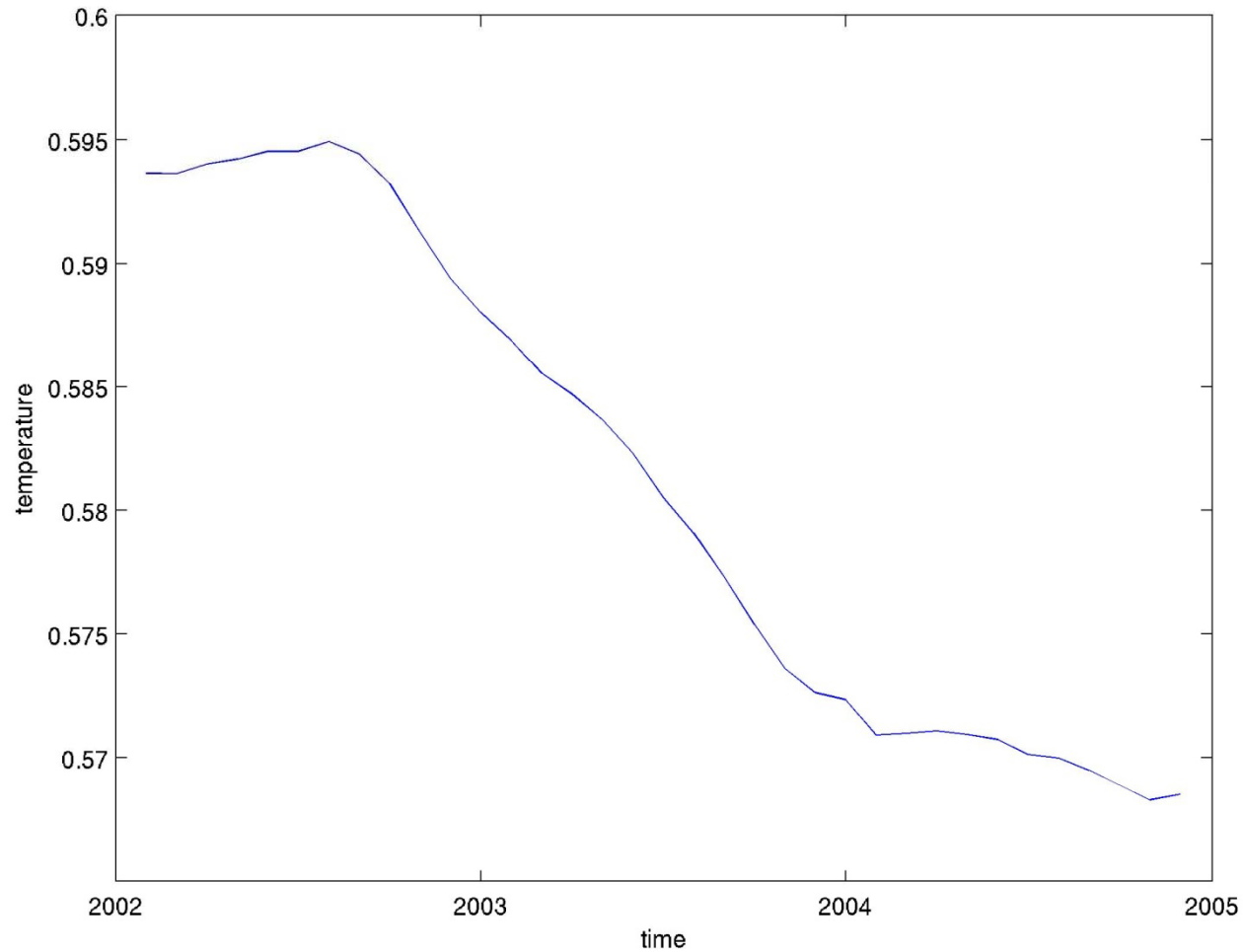
- Ice protection: Antarctic ice sensing was defined
  - If the median of the temperature between 50db and 20db ( $T_{|p=(50,45,40,35,30,25,20 \text{ dbar})}$ ) is less 1.79 °C abort surface attempt
  - Increased the “survival probability” and doubled the life time of floats in ice invested areas.
- Interim storage (iStore) was established
  - For the first time a noteworthy amount of data obtained in ice covered areas.
- Under ice location: RAFOS technique
  - geo-reference of under ice profiles
- **Scientific application**

# Velocity and Temperature from the Floats



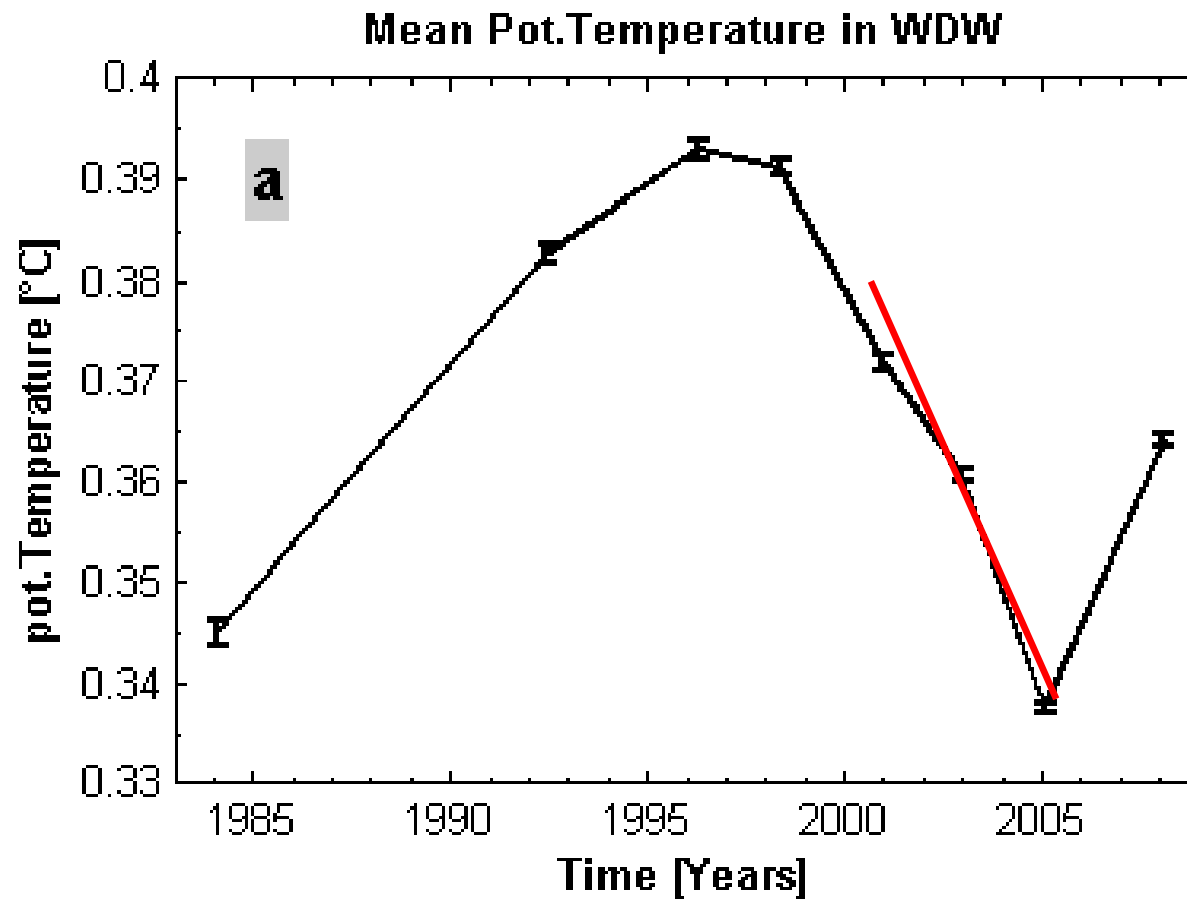
# Float data in combination with a model

Mean temperature of WDW in the Weddell Sea





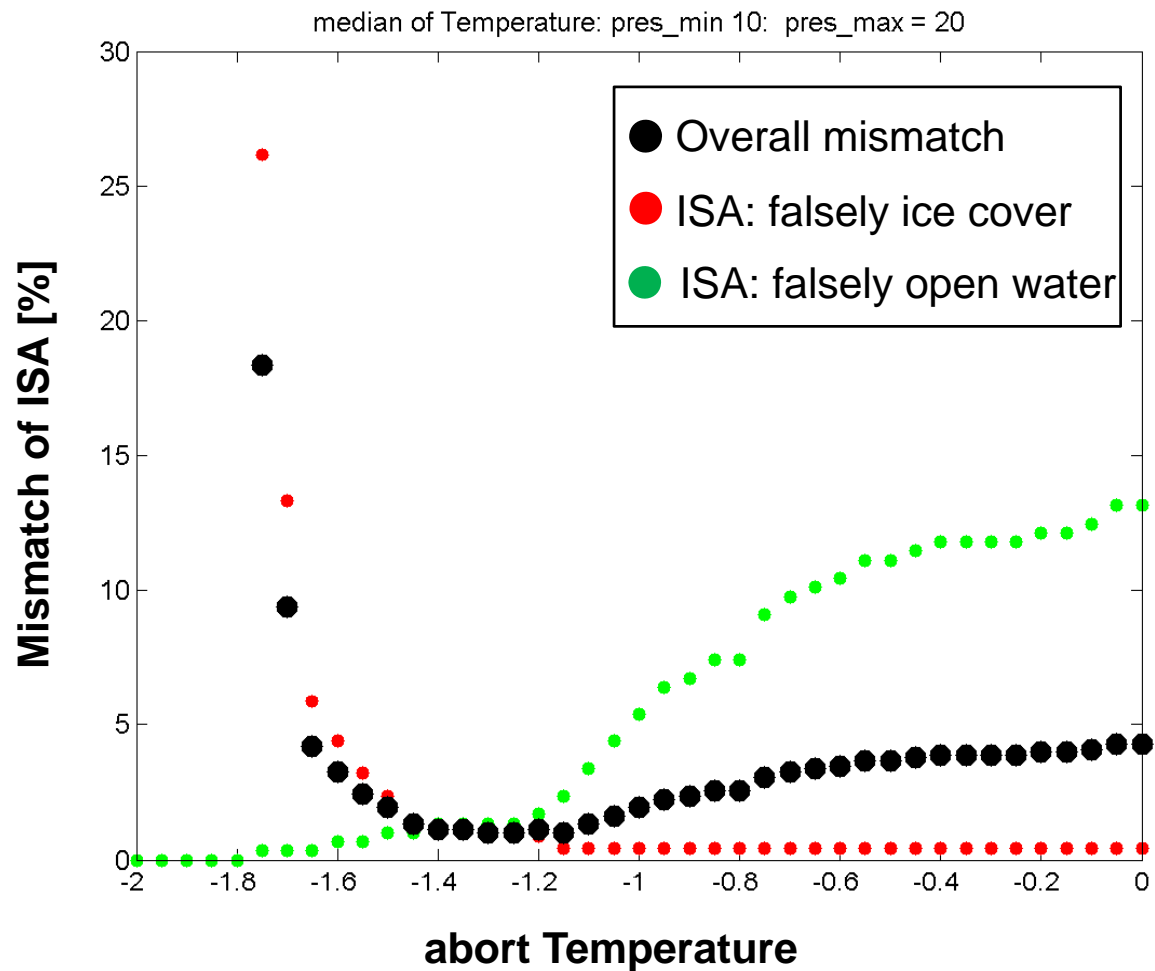
# WDW temperature at Greenwich meridian from CTD sections



# Arctic

- Iridium
  - Arctic ISA (ice-temperature-correlation)
  - Physical ice protection
- 
- New sensor for ice sensing  
photodiode

# Falsely ISA attributed ice conditions

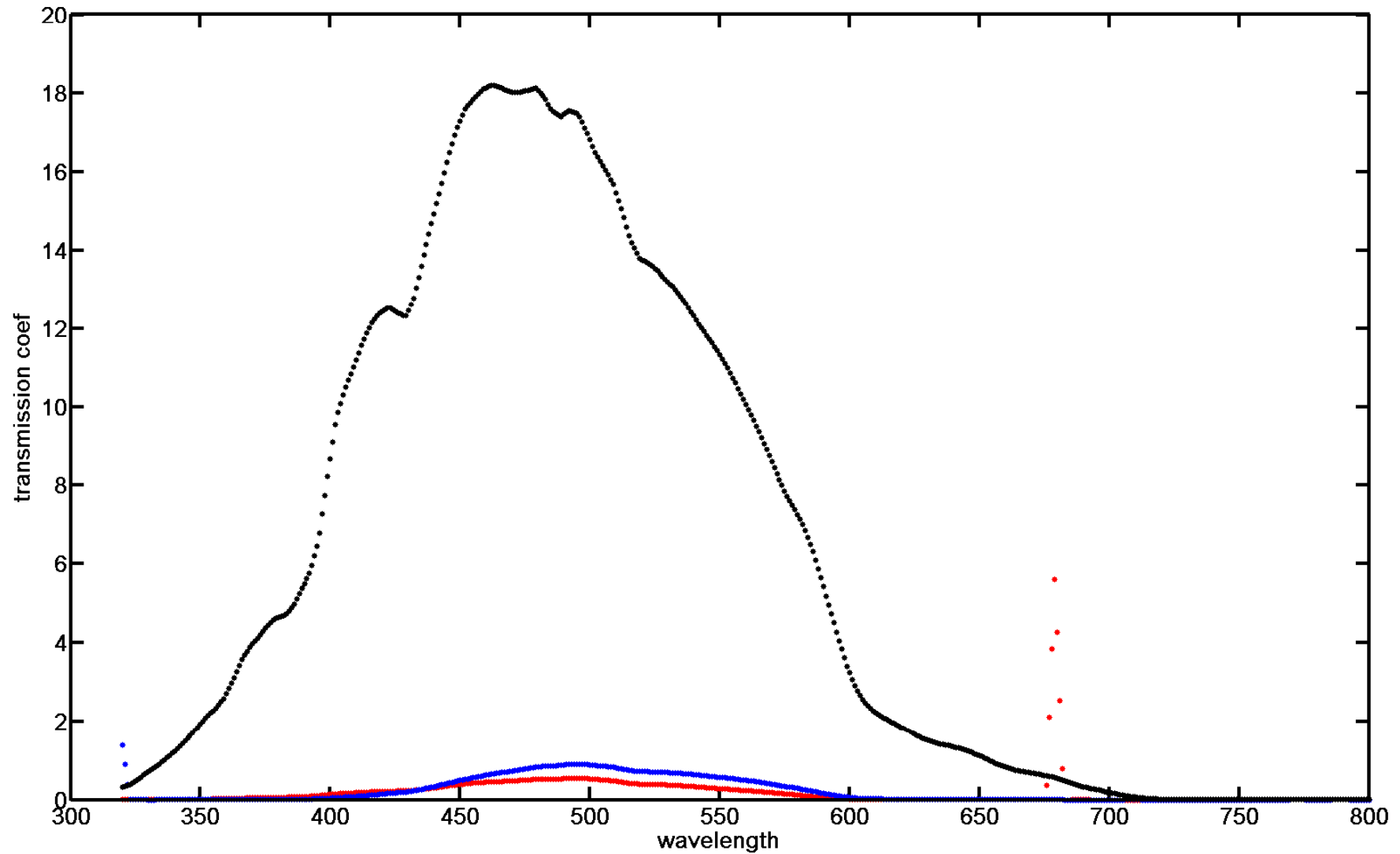


# Ice protection

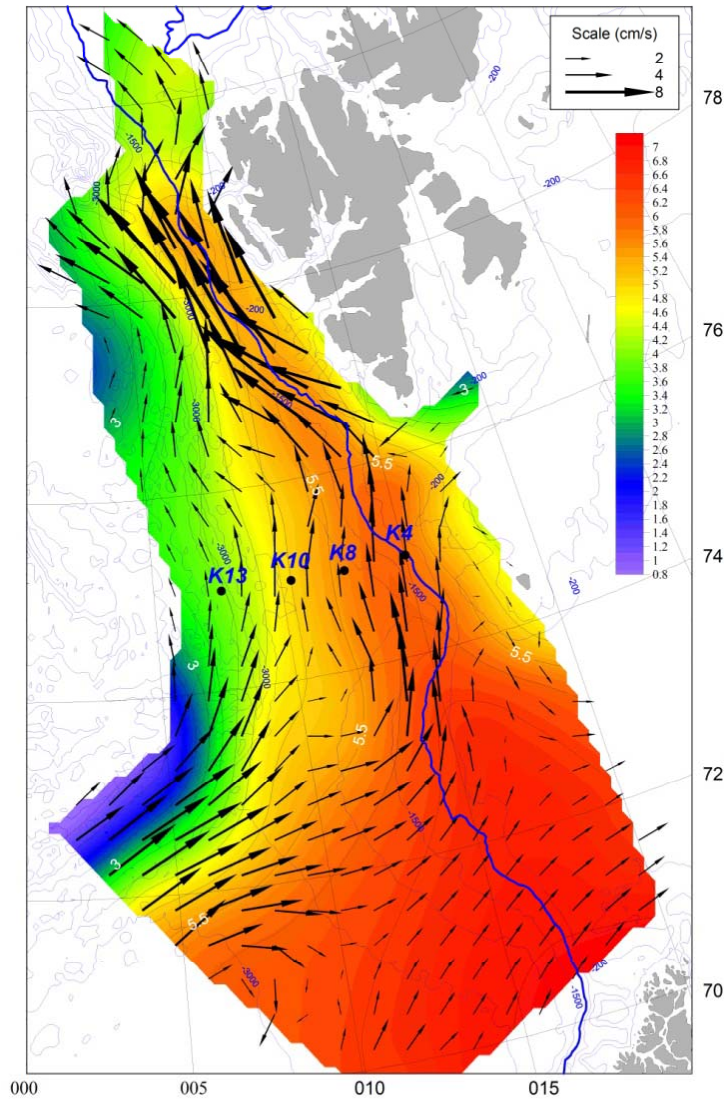


# Outlook: New sensor for ice sensing

Transmission coefficients of water and ice



# Deployment plan: June/July 2010



(personal communication W. Walczowski)